

Thermally-Controlled Variable Parabolicity Antenna Coupled with Structurally-Variied Microwave Diffractive Metamaterial for Energy-Efficient Compact High Spatio-Temporal Resolution Flash LADAR

Pierre L. Coulomb
2026 June 23

Although Flash LiDAR systems have enjoyed a great deal of miniaturization over their 15-year history and can be readily outfitted on seeker heads and small drones, Flash LADAR systems are less compact and are not currently practical for use on drones; particularly man-portable drones. Helical beam systems can overcome atmospheric scattering of light associated with Flash LiDAR systems, but the dehelicization of return impulses limits the usefulness of that approach for remote metrology applications, necessitating the continued use of microwaves as in RADAR systems.

A new approach involving exquisite thermal control over a linear antenna under modest torsional stress and combining this with a metamaterial matrix can enable a high spatio-temporal resolution Flash LADAR system to be operated under conditions of extremely modest available space and electrical energy.

An antenna which is rendered concave by the application of a thermal gradient can produce microwaves which feature a parallax a modest distance from the antenna which varies depending upon the degree of parabolicity of that concave antenna. Heating the ends of a linear antenna and applying a modest amount of force in order to ensure that bowing will occur in the desired direction would create a differential of temperature, the central part of the antenna being cooler than the ends. The resultant warping of the antenna could be exquisitely controlled through a precision thermal control mechanism capable of both cooling and heating the antenna in order to ensure the correct gradient.

This gradient would, by design, run the gamut of possible degrees of parabolicity with each individual scan of the surrounding airspace. The degree of the parabolicity would determine the point of parallax just before the antenna, which would always fall within a three-dimensional metamaterial structure which varies in its characteristics from one layer to the next. The metamaterial would be microwave-diffractive and the point of parallax would determine which of the unique metamaterial layers transmogrifies the beam and, therefore, also determines the unique pattern of multiple beams created by the mesh of the metamaterial.

At each possible "setting," a series of many thousands of sub-beams would be generated of slightly different frequency with large gaps in which no energy is emitted in a given direction. The high degree of focus of the energy would allow for relatively high-amplitude beams to be generated by small platforms such as man-portable drones.

As the antenna goes through each thermal cycle, every possible vector is covered and time of flight analysis is used to determine range. Although these

thermal cycles take several seconds to run through, an array of multiple antenna each with their own thermal control systems can be used in order to allow for continual scanning even whilst the other antennae are recovering from their previous cycles.

So long as the diffractive material can ensure the generation of unique frequencies for each vector and so long as a discrete time-of-flight analysis is possible for a large number of sub-frequencies using the onboard computer, it should be possible to use this method to bestow smaller drones with a long-range RADAR capability capable of sensing aircraft and other drones.